Original Paper

Short-Term Outcomes of Extended Pancreatectomy: A Single-Surgeon Experience

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Keywords

Extended pancreatectomy · Outcomes · Pancreaticoduodenectomy · Vascular resection

Abstract

Background/Aims: The International Study Group of Pancreatic Surgery recently published a consensus statement on the definition of extended pancreatectomy (EP). We aimed to determine the safety profile and short-term outcomes of EP compared to standard pancreatectomy (SP). To mitigate surgeon bias, only pancreatectomies performed by a single surgeon were included. **Methods:** Ninety consecutive patients who underwent pancreatectomy by a single surgeon over a period of 5 years and who met our study criteria were classified into an SP or an EP group. Sixty-two patients underwent pancreaticoduodenectomy (PD), including total pancreatectomy, and 28 patients underwent distal pancreatectomy. **Results:** The 25 patients who underwent EP had significantly increased operation time, estimated blood loss, postoperative intensive care unit (ICU) transfer, and postoperative stay compared to the 65 patients who underwent SP. There was 1 (1.1%) 30-day mortality and 4 (4.4%) in-hospital mortalities. Postoperative morbidity and mortality were similar between both groups. Subgroup analysis of the patients who underwent PD demonstrated that the EP group ($n = 22$) had significantly increased operation time and postoperative ICU transfers. **Conclusion:** Although patients who underwent EP experienced significantly increased operative time, blood loss, and postoperative stay, they did not experience significantly higher postoperative morbidity or mortality compared to patients who underwent SP.

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Introduction

Cancers involving the pancreas and periampullary region have among the highest mortality rates [1]. At present, the only potentially curative treatment available for many of these tumors is complete surgical resection [2, 3]. Although systemic chemotherapy with agents such as 5-FU and gemcitabine is an option, their effect is at most limited. Today, even with complete surgical resection and adjuvant chemotherapy, the median survival rates remain low at 13.4–43.1 months [4–7].

Despite this, improvements in surgical technique, equipment, neoadjuvant chemotherapy, and perioperative support have seen a greater number of patients with advanced disease being offered surgical resection. Accordingly, there has been an escalation in the number of extensive pancreatic resections performed today, adding the prospect of more morbidity to an already morbid operation [8]. Although numerous authors have previously reported their perioperative outcomes of extended pancreatectomy (EP), they utilized various definitions when using the term [9]. Recognizing these limitations and the need for a uniform definition, the International Study Group of Pancreatic Surgery (ISGPS) in 2014 published a consensus paper to standardize the definition of EP [9]. Since then, there have been only two studies reporting on the outcomes of EP according to this definition [10, 11]. The first, a large retrospective study from Heidelberg, examined 611 EP patients compared to 1,217 patients who underwent standard pancreatectomy (SP) over a period of about 12 years. Analysis revealed EP patients to suffer from significantly more morbidity and mortality compared to SP patients [10]. In the second study, De Reuver et al. [11] studied 111 EPs and 66 SPs, but found no difference in mortality and morbidity between them. It is important to note that both studies were based on a multisurgeon experience [10], which may have resulted in biases which can confound results.

In the present study, we aimed to determine the safety and short-term outcomes of EP as defined by the ISGPS in comparison with SP. In order to mitigate biases resulting from surgeon variability, we analyzed only surgeries performed by a single surgeon at a single institution.

Methods

Over a 64-month period from August 2011 to November 2016, 447 patients who underwent pancreatectomy at a single institution were identified from a prospectively maintained database. Of these, 92 consecutive patients who underwent pancreatectomy by a single surgeon (B.K.P. Goh) were identified. These patients were classified as having undergone SP or EP based on the ISGPS consensus definition [9]. Two patients who underwent SP but who had synchronous resections for other indications were excluded.

Clinicopathological data including patient demographics and relevant preoperative, intraoperative, and postoperative outcomes were obtained retrospectively from patient records. Clinical data were collected from a prospective computerized clinical database (Sunrise Clinical Manager version 5.8; Eclipsys Corporation, Atlanta, GA, USA), and patient clinical charts while operative data were obtained from another prospective computerized database (OTM 10; IBM, Armonk, NY, USA).

Definitions

Subtotal pancreatectomy was defined as when the transection of the pancreatic parenchyma was located at or to the right of the portal/splenic vein junction. EP was defined according to the 2014 ISGPS definition [9]. In general, any pancreaticoduodenectomy (PD), distal pancreatectomy (DP), or total pancreatectomy (TP) with adjacent organ resection such as the stomach, colon, or vascular resection due to local tumor involvement was considered an EP.

Postoperative complications were classified according to the Clavien-Dindo grading system [12] and recorded regardless of length of postoperative stay or, if the patient was discharged and readmitted, within a 30-day duration. Pancreatic fistulas were defined and graded according to the latest (2016) Inter-

Table 1. Baseline characteristics of all patients and comparison between EP versus SP

	Total (n = 90)	EP (n = 25)	SP (n = 65)	p value
Age, years	62 (22–82)	65 (44–82)	62 (22–80)	0.304
Age ≥70 years	22 (24.4%)	9 (36.0%)	13 (20.0%)	0.114
Age ≥80 years	2 (2.2%)	1 (4.0%)	1 (1.5%)	0.478
Male	36 (40.0%)	11 (44.0%)	25 (38.5%)	0.631
ASA score				
1	15 (16.7%)	4 (16.0%)	11 (16.9%)	0.891
2	58 (64.4%)	17 (68.0%)	41 (63.1%)	
3	17 (18.9%)	4 (16.0%)	13 (20.0%)	
Charlson-Deyo score				
0	46 (51.1%)	12 (48.0%)	34 (52.3%)	0.459
1	24 (26.7%)	8 (32.0%)	16 (24.6%)	
2	20 (22.2%)	5 (20.0%)	15 (23.1%)	
3	5 (5.6%)	0 (0.0%)	5 (7.7%)	
Malignant tumor				
All	63 (70.0%)	25 (100.0%)	38 (58.5%)	<0.001
Pancreatic adenocarcinoma	41 (45.6%)	22 (88.0%)	19 (29.2%)	
Ampullary carcinoma	9 (10.0%)	0 (0.0%)	9 (13.8%)	
Cholangiocarcinoma	6 (6.7%)	1 (4.0%)	5 (7.7%)	
Duodenal carcinoma	3 (3.3%)	1 (4.0%)	2 (3.1%)	
Others	4 (4.4%)	1 (4.0%)	3 (4.6%)	
Type of pancreatectomy				
Pancreaticoduodenectomy	58 (64.4%)	19 (76.0%)	39 (60.0%)	0.156
Left-sided pancreatectomy	28 (31.1%)	3 (12.0%)	25 (38.5%)	0.015
Total pancreatectomy	4 (4.4%)	3 (12.0%)	1 (1.5%)	0.031
Approach				
Open	61 (67.8%)	23 (92.0%)	38 (58.5%)	0.002
Laparoscopic	29 (32.2%)	2 (8.0%)	27 (41.5%)	

Values are presented as median (range) or n (%). Bold figures indicate statistical significance. ASA, American Society of Anesthesiologists; EP, extended pancreatectomy; SP, standard pancreatectomy.

national Study Group of Pancreatic Fistula grading [13]. Drain fluid amylase was routinely collected on postoperative day 3 and a value >3 times the concentration of the upper limit of serum amylase or a value >300 IU/L associated with a clinically relevant condition was considered a clinically relevant pancreatic fistula. Grade B pancreatic fistula included patients who had surgical drains kept in place for >3 weeks or required endoscopic or percutaneous placement of new drains. Grade C pancreatic fistulas were fistulas which required reoperation, led to organ failure, or resulted in mortality. Purely asymptomatic fistulas previously referred to as a grade A were not classified as a pancreatic fistula or morbidity, but considered a biochemical leak.

Thirty-day mortality was defined as any death within 30 days from surgery, and in-hospital mortality was defined as any death during the index hospital stay regardless of time from surgery. Thirty-day re-admissions were defined as any admission into hospital occurring within 30 days of discharge for any condition related to the primary reason for surgery and the surgery itself.

Statistics

All statistical analyses were performed using the Statistical Package for Social Sciences for Windows, version 21.0 (SPSS Inc., Chicago, IL, USA). Univariate analyses were performed using the Mann-U-Whitney test or χ^2 tests as appropriate. All statistical tests were two-sided, and $p < 0.05$ was considered statistically significant.

Table 2. Perioperative outcomes of all patients and comparison between EP versus SP

	Total (n = 90)	EP (n = 25)	SP (n = 65)	p value
Operation time, min	385 (190–775)	475 (215–775)	340 (190–698)	<0.001
Estimated blood loss, mL	400 (50–4,500)	750 (300–4,500)	300 (50–1,750)	0.001
Immediate postoperative transfers to ICU	15 (16.7%)	9 (36.0%)	6 (9.2%)	0.002
Postoperative stay, days	11 (3–108)	16 (6–108)	10 (3–82)	0.034
Thirty-day readmission	12 (13.3%)	4 (16.0%)	8 (12.3%)	0.644
Postoperative complication	45 (50.0%)	15 (60.0%)	30 (46.2%)	0.153
Major postoperative complication (above grade II)	32 (35.6%)	11 (44.0%)	21 (32.3%)	0.219
Pancreatic fistula				
All	13 (14.4%)	3 (12.0%)	10 (15.4%)	0.682
Grade B	12 (13.3%)	3 (12.0%)	9 (13.8%)	0.817
Grade C	1 (1.1%)	0 (0.0%)	1 (1.5%)	0.533
Biochemical leak	33 (36.7%)	4 (16.0%)	29 (44.6%)	0.012
Mortality				
Thirty-day	1 (1.1%)	0 (0.0%)	1 (1.5%)	0.533
In-hospital	4 (4.4%)	1 (4.0%)	3 (4.6%)	0.899

Values are presented as median (range) or n (%). Bold figures indicate statistical significance. EP, extended pancreatectomy; ICU, intensive care unit; SP, standard pancreatectomy.

Table 3. Organs resected during extended pancreatectomy (n = 25)

Additional organs resected (including vascular resection)	
1	22 (88.0%)
2	2 (8.0%)
3	0 (0.0%)
4	1 (4.0%)
Superior mesenteric vein/portal vein resection	
All	22 (88.0%)
Wedge/sleeve	13 (52.0%)
End-to-end	5 (20.0%)
Interposition graft	4 (16.0%)
Arterial resection	1 (4.0%)
Hepatectomy	2 (8.0%)
Gastrectomy	1 (4.0%)
Colectomy	1 (4.0%)
Choledochectomy	1 (4.0%)
Nephrectomy	1 (4.0%)
Diaphragm	1 (4.0%)
Others	1 (4.0%)

Values are presented as n (%).

Results

Ninety patients who underwent pancreatectomy between 2011 and 2016 met our study criteria. Twenty-five patients underwent EP and 65 patients SP. The baseline clinicopathological features and perioperative outcomes of the 90 patients are summarized in Tables 1 and 2, respectively. The types and number of organs resected during EP are summarized in Table 3. Most of the EPs involved vascular resection. Twenty-two (88.0%) involved resection

Table 4. Summary of the 47 major in-hospital morbidities (above grade II) which occurred in 32 patients

	Total (n = 90)	EP (n = 25)	SP (n = 65)	p value
<i>Grade IIIa</i>				
Total	31 (34.4%)	9 (36.0%)	22 (33.8%)	0.847
Delayed gastric emptying requiring nasojejun tube	18 (20.0%)	6 (24.0%)	12 (18.5%)	0.556
Pancreatic fistulas	12 (12.5%)	3 (12.0%)	9 (13.8%)	0.817
Requiring drainage only	10 (11.1%)	2 (8.0%)	8 (15.4%)	
With bleeding requiring embolization only	1 (1.1%)	1 (4.0%)	0 (0.0%)	
Requiring both drainage and embolization	1 (1.1%)	0 (0.0%)	1 (1.5%)	
Non-PF-related bleeding				
Gastrojejunal staple line bleed	1 (1.1%)	0 (0.0%)	1 (1.5%)	0.533
<i>Grade IIIb</i>				
Total	9 (10.0%)	4 (16.0%)	5 (7.7%)	0.497
Pancreatic fistula requiring reoperation	1 (1.1%)	0 (0.0%)	1 (1.5%)	0.533
Postoperative bleeding	6 (6.7%)	2 (8.0%)	4 (6.2%)	0.702
From pancreatic stump	3 (3.3%)	0 (0.0%)	3 (4.6%)	
From other vessels	3 (3.3%)	2 (8.0%)	1 (1.5%)	
Portal vein/superior mesenteric vein thrombosis	2 (2.2%)	2 (8.0%)	0 (0.0%)	
<i>Grade IV</i>				
All	3 (3.3%)	2 (8.0%)	1 (1.5%)	0.126
Respiratory failure requiring ventilatory support	2 (2.2%)	1 (4.0%)	1 (1.5%)	
Septic shock	1 (1.1%)	1 (4.0%)	0 (0.0%)	
<i>Grade V</i>				
Total	4 (4.4%)	1 (4.0%)	3 (4.6%)	0.689
Pneumonia	3 (3.3%)	1 (4.0%)	2 (3.1%)	
Respiratory arrest from anoxic brain injury	1 (1.1%)	0 (0.0%)	1 (1.5%)	

Values are presented as n (%). Patients may have experienced more than one morbidity. EP, extended pancreatectomy; PF, pancreatic fistula; SP, standard pancreatectomy.

of either the superior mesenteric vein (SMV) or the portal vein. One (4.0%) patient underwent arterial resection and reconstruction, which was done concomitantly with resection of the SMV.

Morbidities

Postoperative morbidity occurred in 45 (50.0%) patients and was not significantly different between both groups. Thirty-two (35.6%) of these were major (above grade II) morbidities, including 18 grade IIIa, 7 grade IIIb, 3 grade IV, and 4 grade V morbidities. Overall, there were 47 different major morbidities occurring in these 32 patients, which are summarized in Table 4.

There were 31 grade IIIa complications which occurred in 27 patients. Of these, the most common was delayed gastric emptying requiring endoscopic insertion of a nasojejun tube ($n = 18$), followed by grade B pancreatic fistulas ($n = 12$). Nine (10.0%) patients experienced grade IIIb complications and required repeat surgery. Six (6.7%) patients underwent re-laparotomy for postoperative bleeding, of which 3 (3.3%) were for pancreatogastrostomy stump bleed, 1 (1.1%) was for middle colic artery bleed, another one (1.1%) was for a jejunal vessel bleed, and the last one (1.1%) was for a bleeding gastrojejunal anastomotic ulcer. Of the remaining 3 patients, 1 patient who had undergone standard PD required a laparotomy with washout and subsequent completion pancreatectomy for pancreatic ascites. Two

others who had EP with venous resection required open thrombectomy for venous thrombosis. One of the 2 patients who underwent EP with SMV resection had repeated thrombosis of the vessel resulting in gastrojejunostomy anastomotic dehiscence and required a second revision of the SMV anastomosis with a polytetrafluoroethylene (PTFE) graft in addition to a refashioning of the gastrojejunostomy anastomosis. Two of the 9 patients (22.2%) who required reoperations eventually demised. One was from nosocomial pneumonia and the other from anoxic brain injury after respiratory arrest.

Overall, 13 patients (14.4%) had pancreatic fistulas, of which 12 (91.7%) were grade B and 1 (8.3%) was a grade C fistula requiring reoperation. One of the grade B fistulas which initially required percutaneous drainage also subsequently required angioembolization for bleeding. Thirty-three patients had a biochemical leak.

Mortality

No difference in mortality was demonstrated between the EP and the SP group. There was one 30-day mortality and 4 (4.4%) in-hospital mortalities (Table 4). Three were due to nosocomial pneumonia and 1 was due to anoxic brain injury from respiratory arrest. The 4 in-hospital mortalities are briefly described as follows. The first mortality was a patient who underwent an extended Whipple procedure with SMV resection and PTFE graft reconstruction for locally advanced pancreatic cancer. Postoperatively she developed upper gastrointestinal bleeding on postoperative day (POD) 15 from a 1-cm gastrojejunostomy ulcer which required reoperation, gastrostomy, and oversewing of the ulcer. She subsequently developed nosocomial pneumonia which resulted in her demise. The second occurred in a post-renal transplant patient who underwent a Whipple procedure for a 7-cm intraductal papillary mucinous neoplasm. She developed a grade B pancreatic fistula which was treated via percutaneous drainage. Although the collections resolved, she developed overwhelming sepsis from nosocomial pneumonia and eventually succumbed. The third mortality occurred in a patient who underwent a Whipple procedure for pancreatic head adenocarcinoma. Postoperatively, he developed a pancreatic fistula requiring endoscopic transgastric drainage on POD 13. He remained stable until POD 49 when he developed pancreatic ascites due to migration of the transgastric stent. He underwent laparotomy and washout, and although the reoperation was uneventful, he developed sudden respiratory arrest and required cardiopulmonary resuscitation in the operating room recovery area immediately after extubation. This was attributed to an idiosyncratic reaction to polymyxin B after general anesthesia, and the patient sustained severe hypoxic brain injury. He remained in a coma and subsequently demised from respiratory failure after 2 months. The final mortality was in an American Society of Anesthesiologists (ASA) score 3 patient who had a recent myocardial infarction 2 months before surgery. He underwent laparoscopic DP for a pancreatic tail adenocarcinoma and postoperatively developed a grade B pancreatic fistula requiring percutaneous drainage. Unfortunately, his stay was complicated by nontraumatic intracranial hemorrhage on POD 10 followed by an acute myocardial infarction on POD 21. He developed further complications of pneumonia and eventually demised on POD 69.

Comparison between the Baseline Characteristics and Outcomes of EP versus SP

There was no difference between the baseline characteristics such as age, sex, ASA score, or Charlson-Deyo score of the two groups on univariate analysis (Table 1). Patients who underwent EP were significantly more likely to have malignant tumors, to undergo open surgery, and to require TP compared to patients who underwent SP. They were also significantly less likely to undergo DP compared to patients who underwent SP. All 25 patients who underwent EP had a malignant tumor, compared to only 38 (58.5%) of those

Table 5. Baseline characteristics and outcomes in the pancreaticoduodenectomy including total pancreatectomy subgroup

	Total (n = 62)	EP (n = 22)	SP (n = 40)	p value
Age, years	63 (44–82)	65 (44–82)	62 (44–79)	0.480
Age ≥70 years	17 (27.4%)	8 (36.3%)	9 (22.5%)	0.242
Age ≥80 years	1 (1.6%)	1 (4.5%)	0 (0.0%)	0.174
Male	28 (45.2%)	10 (45.5%)	18 (45.0%)	0.973
ASA score				
1	9 (14.5%)	3 (13.6%)	6 (15.0%)	0.536
2	40 (64.5%)	16 (72.7%)	24 (60.0%)	
3	13 (21.0%)	3 (13.6%)	10 (25.0%)	
Charlson-Deyo score				
0	27 (43.5%)	10 (45.5%)	17 (42.5%)	0.455
1	19 (30.6%)	8 (36.3%)	11 (27.5%)	
2	12 (19.4%)	4 (18.1%)	8 (20.0%)	
3	4 (0.06%)	0 (0.0%)	4 (10.0%)	
Malignant tumor				
All	55 (88.7%)	22 (100.0%)	33 (82.5%)	0.011
Pancreatic adenocarcinoma	35 (56.5%)	20 (90.9%)	15 (37.5%)	
Ampullary carcinoma	9 (14.5%)	0 (0.0%)	9 (22.5%)	
Cholangiocarcinoma	6 (9.7%)	1 (4.5%)	5 (12.5%)	
Duodenal carcinoma	3 (4.8%)	1 (4.5%)	2 (5.0%)	
Others	2 (3.2%)	0 (0.0%)	2 (5.0%)	
Pancreatic anastomosis reconstruction				
Pancreaticogastrostomy	37 (59.7%)	9 (40.1%)	28 (70.0%)	0.065
Pancreaticojejunostomy	21 (33.9%)	10 (45.5%)	11 (27.5%)	
Total pancreatectomy	4 (6.5%)	3 (13.6%)	1 (2.5%)	
Approach				
Open	57 (91.9%)	21 (95.5%)	36 (90.0%)	0.450
Laparoscopic	5 (8.1%)	1 (4.5%)	4 (10.0%)	
Operation time, min	392.5 (215–770)	480 (215–770)	344.5 (240–698)	<0.001
Estimated blood loss, mL	500 (100–4,500)	700 (300–4,500)	300 (100–1,750)	0.008
Immediate postoperative transfers to ICU	17 (27.4%)	10 (45.5%)	7 (17.5%)	0.018
Postoperative stay, days	15 (7–108)	16 (8–108)	13.5 (7–82)	0.871
Thirty-day readmission	13 (21.0%)	4 (18.2%)	9 (22.5%)	0.689
Postoperative complication	37 (59.7%)	13 (59.1%)	24 (60.0%)	0.944
Major postoperative complication (above grade II)	27 (43.5%)	9 (40.9%)	18 (45.0%)	0.756
Pancreatic fistula				
All	8 (12.9%)	2 (9.1%)	6 (15.0%)	0.507
Grade B	7 (11.3%)	2 (9.1%)	5 (12.5%)	0.685
Grade C	1 (1.6%)	0 (0.0%)	1 (2.5%)	0.455
Biochemical leak	17 (27.4%)	4 (18.1%)	13 (32.5%)	0.227
Mortality				
Thirty-day	1 (1.6%)	0 (0.0%)	1 (2.5%)	0.455
In-hospital	3 (4.8%)	1 (4.5%)	2 (5.0%)	0.936

Values are presented as median (range) or n (%). Bold figures indicate statistical significance. ASA, American Society of Anesthesiologists; EP, extended pancreatectomy; ICU, intensive care unit; SP, standard pancreatectomy.

who underwent SP. Pancreatic cancers made up the bulk of malignant tumors ($n = 41$). Of the 25 EPs, only 2 (8.0%) were performed laparoscopically, compared to 27 (41.5%) surgeries in the SP group.

On univariate analysis, operative time, estimated blood loss, postoperative intensive care unit (ICU) transfer, and postoperative duration of stay were significantly higher in patients who underwent EP compared to those who underwent SP (Table 2). There was no difference in 30-day readmission rates and postoperative complication rates.

Comparison between the Baseline Characteristics and Outcomes of EP versus SP in the 62 Patients Who Underwent PD/TP

Subgroup analysis of patients who underwent only PD including TP revealed no difference between their baseline characteristics, other than patients who underwent EP and were more likely to have malignant tumors (Table 5). Patients who underwent EP were significantly more likely to have a longer operation time and to be transferred to the ICU postoperatively, although there was no significant difference in blood loss, postoperative morbidity, or length of stay.

Discussion

Reinforced by advancements in techniques, equipment, and perioperative care, EP has become increasingly commonplace in the management of locally advanced cancers over the past decade, especially in large tertiary care centers [9]. Underpinning this trend is the fact that pancreatic cancer tends to present late and that complete surgical resection still offers the best chance of disease-specific survival [3, 14, 15]. Indeed, various papers have reported improved 5-year survival rates of between 12% and as high as 27% after resection in recent years [16–19].

In the present study, the vast majority of resections in the EP group were PDs. Although it is difficult to explain the exact reason behind the relatively small numbers of DPs and TPs which were extended resections, possible reasons behind this observation include (1) that pancreatic malignancies in the body and tail frequently present at a late and inoperable stage and most would have presented with metastases, and (2) that locally advanced pancreatic malignancies in the body frequently invade the celiac axis, requiring a DP with celiac axis resection. However, at present we do not routinely perform arterial resection and reconstruction for pancreatic malignancy at our institution, as we believe that aggressive resection for cancers involving the artery may be of little benefit to patient survival.

Unsurprisingly, EP has its attendant costs. Analysis of our EP revealed significant increases in operative time, estimated blood loss, postoperative ICU transfers, and postoperative stay compared to SP. These findings are also largely concordant with the results of other large studies reported by other authors [11, 20–22]. In our present study, no difference in postoperative morbidity or mortality rates between EP and SP was demonstrated. This was in agreement with the study by Nikfarjam et al. [22], who also reported similar morbidity and mortality in their study of 105 patients who underwent PD. Likewise, De Reuver et al. [11] found no difference in either perioperative morbidity (38% in SP vs. 35% in EP) or mortality (0% for both) in his study of 177 patients who underwent PD for ductal adenocarcinoma. Similar findings were also reported for patients who underwent DP with multivisceral resection by Seeliger et al. [23] and Sahakyan et al. [24], both of whom reported comparable morbidity but not mortality rates, and Panzeri et al. [25], who reported comparable morbidity and mortality rates.

This highlights an important point, namely that although one would logically expect EP to be associated with a higher morbidity compared to SP due to the magnitude of the surgery, on the contrary, these resections frequently are associated with a decreased rate of pancreatic fistula, which is the most common and dreaded morbidity after pancreatectomies. This is because patients who undergo EP frequently have locally advanced pancreatic malignancies which are associated with a firm pancreas and dilated pancreatic duct, compared to SP for early periampullary cancers or premalignant tumors which are associated with a soft pancreas and small duct. Nonetheless, in this study SP was only significantly associated with a higher rate of biochemical leak but not clinically significant pancreatic fistula, possibly due to the small sample size resulting in a type 2 error.

Larger studies which included the various types of pancreatectomies have found contrasting results. Bhayani et al. [21] analyzed 273 extended PDs from the National Surgical Quality Improvement Project database over 6 years and found significantly increased morbidity and a three-fold increase in mortality compared to patients who underwent SP. Hartwig et al. [20] found increased morbidity but comparable mortality in their 2009 matched-pair analysis of 101 patients who underwent multivisceral pancreatic resection. In their study however, patients with additional portal vein resection or splenectomy that was not done in the context of DP or TP were not considered as having undergone multivisceral resection, although they were included in the analysis of morbidity and mortality. In their more recent study of over 1,800 patients who underwent pancreatectomy for borderline resectable tumors, Hartwig et al. [10] found significantly increased rates of delayed gastric emptying, re-laparotomy, and mortality in patients who underwent EP. With respect to DP, multivisceral resection has also been found to increase the odds of overall morbidity [26, 27].

Long-Term Outcomes

Studies examining the long-term survival outcomes in EP are limited with conflicting results. Various studies have showed improved survival [28], with some quoting comparable 5-year rates of 16–35.5% [29–31]. In contrast, other studies have demonstrated a significant difference in favor of the standard resection group. In the study by Hartwig et al. [10], both median and 5-year survival rates were reduced in the EP group, even after correcting for perioperative mortality. Sahakyan et al. [24] reported a decreased median survival times of 20.2 months in the EP group versus 33.3 months in the SP group in their series of 196 laparoscopic DPs. Similarly, De Reuver et al. [11] also reported decreased survival times of 18.5 months in the EP group versus 32.1 months in the SP group in their PD series. These studies have also identified a multitude of factors such as increased age [10], higher tumor grade [10, 11, 29], larger tumor size [28, 32], positive lymph nodes [10, 11, 29], incomplete resection [10, 11], perineural invasion [11], prolonged operating time [10], intraoperative transfusion [28], and increased blood loss [10] as negative predictive factors for long-term survival.

Vascular Resection

Comparatively, pancreatectomy with vascular resection, a subset of EP, has been demonstrated by large studies [33–35], including systematic reviews [36–38] and a meta-analysis [39], to be largely of comparable morbidity, mortality, and long-term outcomes to SP. The only point of contention lies with arterial resections, with one study showing a poorer survival rate despite reducing the risk of local tumor recurrence [40], and a meta-analysis showing increased perioperative and long-term mortality [41]. Only Christians et al. [42] managed to achieve similar morbidity and mortality rates in their carefully selected group of patients who underwent neoadjuvant chemotherapy. Considering that the vast majority (84.0%) of our EP patients underwent only venous resection, our results are consistent with those of the above studies. Furthermore, this suggests that the poorer outcome of EP patients seems to stem from the concomitant organ resection, an observation supported by Hartwig et al.'s 2009 paper on multivisceral resection [20]. Despite this, in their more recent study, multiorgan resection and arterial resection were not shown to increase mortality on multivariate analysis, although they were significant on univariate analysis [10]. Thus, further analysis and research is still required to establish this postulation.

Limitations

There are several potential limitations associated with this study. Firstly, due to the relatively small sample size, the statistical analysis could have been affected by a type 2 error. Secondly, the data only represent the experience of a single surgeon in a tertiary-level center,

which may limit its generalization to other institutions. However, in our opinion the inclusion of only cases performed by a single surgeon over a relatively short time span is a major strength of our study, as it mitigates biases arising from previous studies which included EP performed by multiple surgeons over a relatively long time period.

Conclusion

In this single-surgeon study, we found that although patients who underwent EP experienced significantly increased operative time, blood loss, and postoperative stay, they did not experience significantly higher postoperative morbidity or mortality compared to patients who underwent SP.

Statement of Ethics

The study was approved by the SingHealth Institutional Review Board.

Disclosure Statement

The authors declare no conflicts of interest.

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